Materials Engineering Branch

TIP*

No. 025 Moisture Effects on Composites

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Advanced composites that consist of a thermoset resin matrix reinforced with fibers of graphite, boron or Kevlar can absorb moisture from the atmosphere. This absorbed moisture causes the matrix to swell, lowers the polymer's glass transition temperature and affects matrix-dominated properties. Transverse tensile, transverse modulus and in plane shear are lowered especially as the temperature is increased. Figure 1 is a comparison of the weight gain for two neat (no fibers) resins that are commonly used in the aerospace industry for carbon fiber composites.

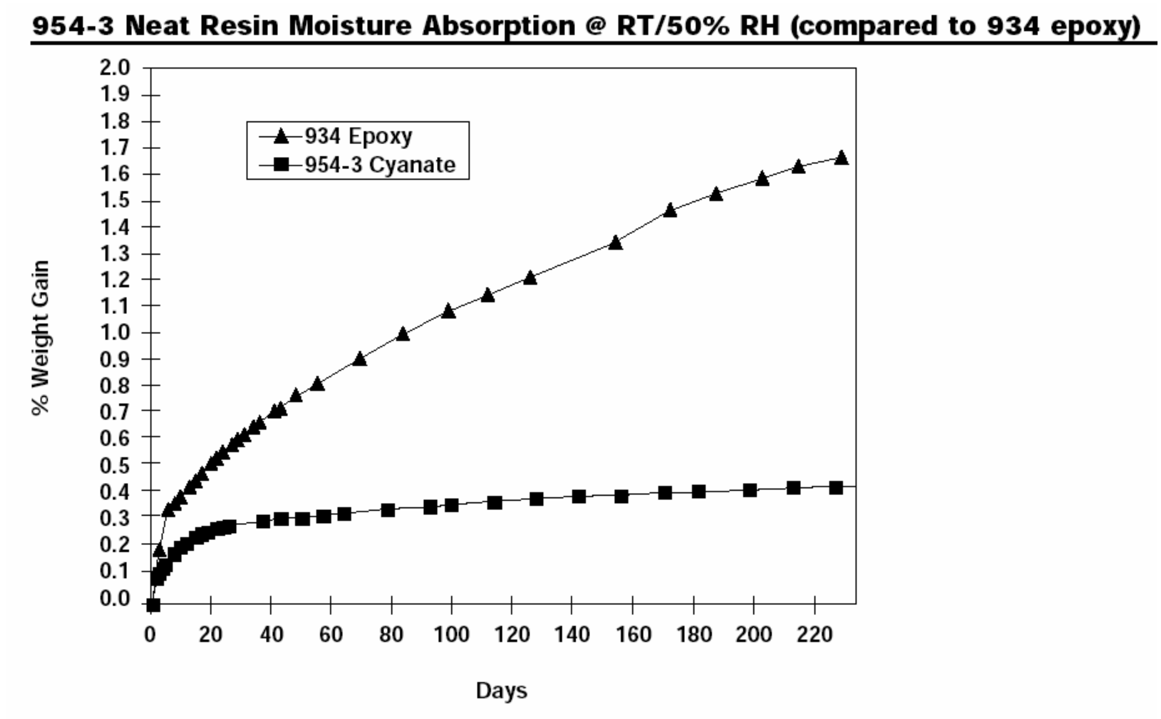

Figure 1: Weight gain versus time for epoxy and cyanate ester resins from Hexcel Composites.[Reproduced from Hexcel's Satellite_Prepreg_954-3.pdf]

In precision instrument structures composed of multi-directional angle ply laminates, dimensional changes caused by loss of water in the vacuum of space can be either positive or negative. Coefficients of moisture expansion (CME) analogous to coefficients of thermal expansion have been measured for various composites. The CME is defined as the change in length per unit length per weight percent of water absorbed into the composite. Table I shows the CME for a cyanate ester resin cured at 350° F.

Table 1: CME of a cyanate ester resin from Hexcel Composites
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Dimensional Stability

	954-3[1]	**954-3**[2]
Hygrostrain, ppm	18.9	108
Water Absorption, %	0.18[3]	0.70[4]
CME, ppm %	105	155

Notes: Hygrostrain divided by %M = CME
Pseudo-isotropic P75 laminates; 30% RC
[1]R. Brand and E. Derby; SPIE conf, 1690, 309. April 1992 (Composite Optics, Inc.)
[2]C. Blair and J. Zakrzewski, SPIE Conf. 1690, 300. April 1992 (Lockheed MSC)
[3]55% RH/EQ
[4]50% GH/EQ

To design the most dimensionally stable structure, select the lowest moisture-absorbing matrix resin and/or cover the surface with a moisture barrier layer. Epoxy neat resins absorb more moisture than cyanate ester resins (4 to 7% for epoxies vs. 0.6 to 2.5% for cyanate ester resins). Moisture barriers of metal foils or electroplated films have been successfully used in the past.

Since each fiber/matrix system will behave differently, the material selected for a precision structure should be tested for moisture absorption properties and equilibrium conditioned per ASTM D 5229/D5229M and be measured for its particular CME.